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Biomass and Nutrient Content of Green Material the Size of Medium and Large Litter

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North Central Forest Experiment Station
USDA Forest Service
1992 Folwell Avenue
St. Paul, Minnesota 55108

(252)

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PROGRESS REPORT

Title "BIOMASS AND NUTRIENT CONTENT OF GREEN MATERIAL
THE SIZE OF MEDIUM AND LARGE LITTER"

Master Study: "Nutrient cycling and energy flow in the aspen community involving the forest tent caterpillar, the host tree, and forest litter."

by

William E. Miller

Division of Continuing Research

NOT FOR PUBLICATION

TABLE OF CONTENTS

REPORT SUMMARY

Fifty-four primary branches from lower, middle, and upper crown thirds and 18 mid-stem bolts were collected in mid-June from 18 quaking aspen trees 9.0-23.1 cm dbh at 3 study locations. Most branches were in the size range of medium litter and bolts were in the size range of large litter as defined in the First-Year Progress Report. Foliage was removed from branches. Green volume of bolts was determined and all material oven-dried at 70 C to constant weight. Branches and bolts were milled individually without separation of bark to pass a 40-mesh screen and concentrations of 13 elements determined. The biomass/volume relation for bolts proved essentially the same as for large litter accumulating semiannually in catchments, the proportionality factor being 0.364, as developed in the First-Year Progress Report. Mean percentage concentrations of nutrients ranged among locations as follows: in branches, nitrogen (N), 0.32-0.35; phosphorus (P), 0.05-0.06; potassium (K), 0.30-0.34; Calcium (Ca), 1.2-1.5; and Magnesium (Mg), 0.13-0.14; in bolts, N, 0.14-0.18; P, 0.02-0.03; K, 0.11-0.14; Ca, 0.4-0.5, and Mg, 0.06-0.07. Branches were richer in all nutrients than bolts. Concentrations of N, P, K, and Mg averaged highest in upper crown branches which had the smallest diameters and highest ratios of bark to wood. Concentration of Ca averaged highest in lower crown branches. Concentrations of N, P, K, Ca, and Mg were higher in green material than catchment litter. Among locations, the factors ranged as follows: for branches, N, 1.1-1.4; P, 2.5-3.0; K, >1.9->3.4; Ca, 1.4-1.8; and Mg, 1.8-2.6; for bolts, N, 1.2-1.8; P, >1.0->1.5; K, 0.8-1.2; Ca, 0.7-1.5; and Mg, 0.9-1.2. Because of possible seasonal variation, green material in mid-June may not represent original nutrient concentrations for all litter but data in this report provide a first approximation.

INTRODUCTION

The First-Year Progress Report detailed biomass and nutrient content of medium and large litter that accumulated in catchments during the 1972 growing season and 1972-73 dormant season. The Report noted that much medium and large catchment litter had been standing dead. Biomass and nutrients of standing dead material are doubtless reduced by leaching and biological degradation but standing dead material does not register as litter until it falls in a catchment. Catchment material may not provide an accurate measurement of medium and large litter biomass and nutrients being cycled if change has been extensive during the standing period. The First-Year Progress Report concluded that original biomass and nutrient levels of material in medium and large litter catchments should be determined. The present Progress Report details biomass and nutrients in green material the same size as medium and large litter and compares results with values for medium and large litter at the same study locations.

Progress Reports on this Master Study primarily summarize data and describe results. Full interpretation and integration will be deferred to later reports.

METHODS

Green material of medium and large litter size was collected June 16-23, 1974, from 18 trees at 3 study locations. All were quaking aspen also used to estimate insect density and were selected by a combination systematic-random process. Origin of the material is shown in Table 1.

After felling, crowns were subdivided into lower, middle, and upper thirds. One primary branch was arbitrarily selected from each third of each crown, sawed off near its base, all foliage removed, then trimmed apically to approximately 1 m in length. One bolt was sawed out near the middle of each stem as measured from ground to top of crown. Branches and bolts were brought to the laboratory in St. Paul.

Table 1.--Origin of trees sampled for green material of medium and large litter size. Each plot provided one tree.

Location (No.)	Quadrant and plot No.
Black River (01)	154
	161
	364
	406
	422
	440
Telephone (02)	117
	212
	221
	318
	410
	453
Pine Stump (03)	241
	342
	357
	362
	428
	446

In the laboratory, dimensions of bolts were measured within 10 days of collection to the nearest 0.1 cm and green volume computed. Bolts and branches were oven-dried to constant weight at 70 C and individually hammer-milled and Wiley-milled to pass a 40-mesh screen. Wood and bark were not separated. N was analyzed in our laboratory by Kjeldahl procedures and 12 other elements at the Department of Soil Science, University of Minnesota, by emission spectrometry (ES) (1.5-m Jarrel-Ash spark emission spectrometer—direct reader).

RESULTS

Biomass. Green volume and dry weight of stem bolts, all of which were large-litter size, are shown in Table 2. When plotted on the graph of dry weight/volume established from large litter accumulated semiannually in catchments, green material differed little (Figure 1). Essentially the same dry weight/volume regression holds for green material as for large catchment litter.

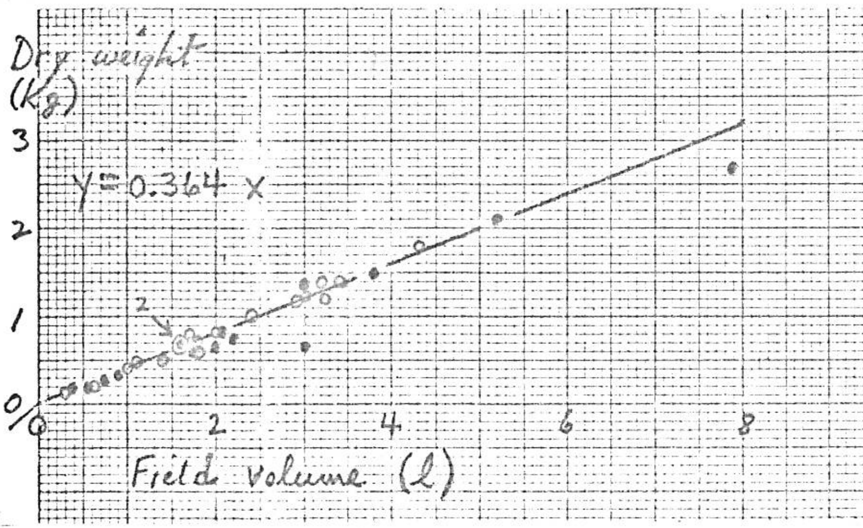
No dry weight/volume check was carried out for material of medium-litter size as medium litter in catchments is measured directly by weighing.

Nutrient concentration. Results of analyses for N, P, K, Ca, and Mg are shown by individual branches and stem bolts in Tables 3-5 and summarized in Table 6. These elements are the more ecologically important ones; ES analyses for 8 additional elements were not summarized but are available in the study file.

Table 2.--Green dimensions and oven-dry weights (70° C)

of stem bolts.

Bolt No.	End Diams. (cm)	Length (cm)	Volume (1)	Oven-dry wt. (kg)
1	9.8, 10.2	40.7	3.20	1.24
2	6.4, 6.4	49.1	1.58	0.68
3	8.3, 8.8	49.9	2.86	1.24
4	9.8, 10.1	41.8	3.25	1.36
5	7.4, 8.0	36.9	1.72	0.85
6	9.2, 9.6	49.3	3.42	1.35
7	7.4, 7.6	44.5	1.97	0.78
8	6.9, 7.6	34.3	1.42	0.53
9	3.4, 3.4	34.4	0.31	0.14
10	6.6, 7.4	41.5	1.60	0.67
11	9.3, 9.4	35.4	2.43	1.01
12	6.6, 6.7	31.0	1.08	0.46
13	8.9, 9.2	46.6	3.00	1.27
14	4.3, 4.6	36.3	0.56	0.22
15	12.2, 12.5	35.9	4.30	1.80
16	7.1, 7.4	42.4	1.75	0.70
17	7.5, 8.2	36.4	1.76	0.65
18	4.5, 4.8	62.4	1.06	0.40



Regression of oven-dry weight on field volume, large litter. Each point represents one or two bolts. Solid circles are litter; open circles are green equivalents.

Figure 1. Dry weight/volume data for 18 green bolts of large litter size plotted with data for large litter from catchments. Litter data and regression from First-Year Progress Report.

Table 3.--Nutrient concentration of branches and stem bolts, Black River (Location 01).

Quadrant and plot No.	Tree size class[1] and dbh (cm)	Category	Crown third	Percentage				
				N	P	K	Ca	Mg
422	Large (16.7)	Branch	Lower	0.23	.03	.15	0.77	.11
		Branch	Middle	.25	.05	.20	0.63	.11
		Branch	Upper	.38	.06	.27	0.84	.16
		Stem	--	.15	.03	.12	0.36	.07
154	Small (10.1)	Branch	Lower	.28	.04	.23	2.12	.13
		Branch	Middle	.30	.05	.33	2.79	.17
		Branch	Upper	.33	.07	.37	2.18	.14
		Stem	--	.15	.02	.10	0.74	.06
440	Medium (15.6)	Branch	Lower	.26	.04	.31	1.32	.15
		Branch	Middle	.41	.07	.38	1.34	.16
		Branch	Upper	.40	.06	.33	1.05	.15
		Stem	--	.15	.02	.10	0.45	.07
364	Medium (17.0)	Branch	Lower	.33	.04	.16	1.02	.14
		Branch	Middle	.27	.04	.23	1.03	.15
		Branch	Upper	.40	.10	.51	1.13	.20
		Stem	--	.12	.02	.09	0.55	.07
406	Large (23.1)	Branch	Lower	.19	.03	.22	1.01	.12
		Branch	Middle	.34	.05	.32	1.03	.15
		Branch	Upper	.34	.05	.32	0.62	.12
		Stem	--	.19	.03	.12	0.28	.06
161	Small (11.6)	Branch	Lower	.25	.05	.30	1.48	.12
		Branch	Middle	.35	.04	.23	1.67	.12
		Branch	Upper	.48	.08	.49	2.47	.16
		Stem	--	.10	.02	.13	0.49	.07

1/ Relative size compared subjectively with neighbors.

Table 4.--Nutrient concentration of branches and stems, Telephone (Location 02).

Quadrant and plot No.	Tree size class[1/] and dbh (cm)	Category	Crown third	Percentage				
				N	P	K	Ca	Mg
410	Medium (14.2)	Branch	Lower	0.23	.06	.31	2.25	.15
		Branch	Middle	.27	.06	.24	1.15	.13
		Branch	Upper	.36	.05	.24	0.90	.12
		Stem	--	.18	.02	.07	0.40	.05
453	Large (14.9)	Branch	Lower	.24	.04	.22	0.93	.14
		Branch	Middle	.19	.04	.20	0.67	.13
		Branch	Upper	.58	.12	.57	0.90	.19
		Stem	--	.14	.03	.13	0.36	.09
318	Small (11.6)	Branch	Lower	.38	.05	.27	2.00	.15
		Branch	Middle	.40	.06	.49	2.62	.16
		Branch	Upper	.45	.07	.48	1.80	.10
		Stem	--	.17	.02	.12	0.65	.07
117	Medium (13.3)	Branch	Lower	.25	.04	.22	1.26	.12
		Branch	Middle	.47	.07	.41	1.63	.13
		Branch	Upper	.28	.05	.28	0.83	.10
		Stem	--	.22	.02	.12	0.49	.07
212	Large (13.9)	Branch	Lower	.22	.05	.23	0.99	.11
		Branch	Middle	.21	.04	.15	0.55	.08
		Branch	Upper	.36	.05	.23	0.61	.11
		Stem	--	.17	.02	.09	0.33	.06
221	Small (9.0)	Branch	Lower	.35	.04	.28	1.02	.15
		Branch	Middle	.50	.06	.35	1.23	.20
		Branch	Upper	.51	.07	.39	0.96	.20
		Stem	--	.18	.02	.11	0.44	.10

1/ Relative size compared subjectively with neighbors.

Table 5.--Nutrient concentration of branches and stems, Pine Stump (Location 03).

Quadrant and plot No.	Tree size class[1/] and dbh (cm)	Category	Crown third	Percentage				
				N	P	K	Ca	Mg
241	Large (14.0)	Branch	Lower	0.26	.04	.27	1.13	.10
		Branch	Middle	.21	.04	.25	0.76	.10
		Branch	Upper	.44	.07	.35	1.00	.12
		Stem	--	.12	.03	.12	0.34	.06
446	Medium (14.1)	Branch	Lower	.25	.04	.26	1.85	.10
		Branch	Middle	.33	.06	.37	1.25	.11
		Branch	Upper	.48	.10	.62	1.98	.12
		Stem	--	.18	.04	.19	0.54	.06
357	Large (19.2)	Branch	Lower	.20	.04	.25	1.20	.09
		Branch	Middle	.27	.06	.30	0.82	.10
		Branch	Upper	.50	.08	.45	0.84	.11
		Stem	--	.14	.03	.14	0.35	.04
342	Small (11.2)	Branch	Lower	.23	.05	.22	1.33	.14
		Branch	Middle	.38	.08	.43	2.07	.16
		Branch	Upper	.23	.05	.26	1.26	.12
		Stem	--	.17	.02	.15	0.59	.08
428	Medium (14.9)	Branch	Lower	.25	.05	.29	1.61	.09
		Branch	Middle	.27	.07	.30	1.16	.09
		Branch	Upper	.50	.11	.46	1.06	.10
		Stem	--	.14	.04	.14	0.44	.05
362	Small (10.9)	Branch	Lower	.29	.06	.30	2.53	.19
		Branch	Middle	.34	.07	.31	2.54	.24
		Branch	Upper	.55	.09	.45	2.44	.21
		Stem	--	.15	.02	.10	0.77	.08

[1/] Relative size compared subjectively with neighbors.

Table 6.--Summary of nutrient concentrations by location.

Location No.	No. trees	Mean dbh (cm)	Category	Crown third	Percentage				
					N	P	K	Ca	Mg
01	6	15.7	Branch	Lower	0.26	.04	.23	1.3	.13
			Branch	Middle	.32	.05	.28	1.4	.14
			Branch	Upper	.39	.07	.38	1.4	.16
				Grand Mean	.32	.05	.30	1.4	.14
			Stem	--	.14	.02	.11	0.5	.07
02	6	12.8	Branch	Lower	.28	.05	.26	1.4	.14
			Branch	Middle	.34	.06	.31	1.3	.14
			Branch	Upper	.42	.07	.36	1.0	.14
				Grand Mean	.35	.06	.31	1.2	.14
			Stem	--	.18	.02	.11	0.4	.07
03	6	14.1	Branch	Lower	.25	.05	.26	1.6	.12
			Branch	Middle	.30	.06	.33	1.4	.13
			Branch	Upper	.45	.08	.43	1.4	.13
				Grand Mean	.33	.06	.34	1.5	.13
			Stem	--	.15	.03	.14	0.5	.06

A few branches from lower and middle crown thirds were large-litter size but most were medium-litter size.

Nutrient concentration of green material appears related to size of the material. Concerning N, P, K, and Mg, concentrations averaged higher in upper crown branches than lower in 11 of 12 cases, and higher in branches than stem bolts in all 12 cases (Table 6). Upper crown branches were smallest. Ca behaved differently. Although branches had higher Ca concentrations than stem bolts (Table 6), in 13 of 18 trees lower crown branches had higher concentrations than upper crown branches (Tables 3-5). A similar difference pattern in nutrient concentration is evident between small and large trees within locations. P changed most among crown levels.

The pattern of N, P, K, and Mg concentration is doubtless due to higher concentrations in bark than wood and to the increasing proportion of bark in material of decreasing size. Conversely, Ca concentration could be related to wood quantity, at least among branches of different crown levels. Also, upper crown branches are younger wood than lower. However, stem bolts with their large wood volume did not have higher concentrations of Ca than branches. Ca concentration varied more among trees than other nutrients. Ca means were fairly stable (Table 6), but individual values at the same crown level ranged widely as follows:

Location No.	Crown Level	No. Trees	Range in % Ca
01	Lower	6	0.77 - 2.12
	Middle	6	0.63 - 2.79
	Upper	6	0.62 - 2.47
02	Lower	6	0.93 - 2.25
	Middle	6	0.55 - 2.62
	Upper	6	0.61 - 1.80
03	Lower	6	1.13 - 2.53
	Middle	6	0.76 - 2.54
	Upper	6	0.84 - 2.44

Precision of ES analysis was checked by systematically including triplicate subsamples of 8 samples. All triplicate values of P, K, Ca, and Mg fell within 9 percent of triplicate means, and most values were closer. Sources of this variability are imperfect subsampling and weighing as well as analytical imprecision.

Close comparison of nutrient concentrations between green material and catchment litter was possible for N, Ca, and Mg and less exact comparison for P and K. Some values of P and K in catchment litter were outside ES detection ranges.

Green material corresponding in size to medium litter averaged 1.1-1.4 more N, 2.5-3.0 more P, >1.9->3.4 more K, 1.4-1.8 more Ca, and 1.8-2.6 more Mg (Table 7). Green material corresponding in size to large litter averaged 1.2-1.8 more N, >1.0->1.5 more P, 0.8-1.2 more K, 0.7-1.5 more Ca, and 0.9-1.2 more Mg (Table 7). These comparisons suggest that medium and large litter release nutrients at different rates. There may be greater leachability and biological degradation in medium than in large litter. On the average, medium litter released less N than large before falling into catchments but large litter retained

Table 7.--Comparison of nutrient concentrations in green material and catchment litter. Stem category corresponds to large litter and branch category chiefly to medium litter.

Location No.	Category	Percentage		Ratio green/catchment litter
		Green	Catchment litter[1]	
		NITROGEN		
01	Branch[2]	0.32	0.28	1.1
	Stem	.14	.08	1.8
02	Branch	.35	.25	1.4
	Stem	.18	.15	1.2
03	Branch	.33	.24	1.4
	Stem	.15	.13	1.2
		PHOSPHORUS		
01	Branch	0.05	0.02	2.5
	Stem	.02	<.02	>1.0
02	Branch	.06	<.021	>2.9
	Stem	.02	<.02	>1.0
03	Branch	.06	.02	3.0
	Stem	.03	<.02	>1.5
		POTASSIUM		
01	Branch	0.30	<0.11	>2.7
	Stem	.11	.14	0.8
02	Branch	.31	<.16	>1.9
	Stem	.11	.14	0.8
03	Branch	.34	<.10	>3.4
	Stem	.14	.12	1.2
		CALCIUM		
01	Branch	1.4	0.97	1.4
	Stem	0.5	.71	0.7
02	Branch	1.2	.81	1.5
	Stem	0.4	.41	1.0
03	Branch	1.5	.82	1.8
	Stem	0.5	.34	1.5
		MAGNESIUM		
01	Branch	0.14	0.08	1.8
	Stem	.07	.08	0.9
02	Branch	.14	.08	1.8
	Stem	.07	.06	1.2
03	Branch	.13	.05	2.6
	Stem	.06	.05	1.2

Footnotes on next page.

Table 7. - Footnotes

[1]Values from First-Year Progress Report. They are based on medium and large litter accumulating during the growing season (May-October). Nutrient content of growing season litter differs little from that of dormant season litter, but 72-94 percent of annual accumulation fell during the growing season at four study locations.

[2]Grand mean for branches from lower, middle, and upper crown thirds.

Ca, Mg, and possibly K longer. Large litter probably remains standing dead longer than medium litter and releases its bark-centered nutrients sooner than its wood-centered nutrients.

Nutrient concentrations in green material in mid June probably do not represent the original condition of all medium and large litter. Nutrient concentrations in branches and stems might vary seasonally as nutrients leach and translocate from senescent leaves to branches, stems and roots. Trees succumbing to suppression or other stress agencies might also translocate nutrients to clonal root systems. The quantities of leaching and translocation are not known but this investigation suggests that substantial amounts of nutrients from branches and stems enter the litter system before medium and large litter biomass reaches catchments. If nutrient cycling rates by medium and large litter require adjustment for modeling, data in this Progress Report provide a first approximation of original concentrations involved.